THE

AMERICAN JOURNAL

OF THE MEDICAL SCIENCES.

FEBRUARY, 1906.

SPECIAL ARTICLE.

ON THE EXTERMINATION OF THE MOSQUITO.

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The investigation of the mosquito in the United States during the past few years has contributed much valuable information regarding the propagation of this insect, its habits, its relation to disease, and the means by which it can be exterminated. This has been particularly satisfactory, inasmuch as those who have been active in the investigation, and who have worked independently of each other, have arrived at practically the same conclusions, which is additional evidence of the value and thoroughness of the work. The results obtained in Havana by Dr. Walter Reed and his associates, who composed the Board appointed by the United States Government to investigate the cause of yellow fever, must be regarded as conclusive evidence that this disease is transmitted by the variety of mosquito known as the *stegomyia*, and thus far no evidence has been presented to show that it is transmitted in any other way. The value of this discovery cannot be overestimated, inasmuch as it points out the means by which the propagation of yellow fever may be prevented. It has also given an impulse to further investigation of the mosquito in this country, although the more recent investigation has rather been directed toward securing such information as will lead to the extermination of this insect. We are now familiar with practically every variety of the mosquito which propagates in the United States, or at least those varieties which usually annoy us, among which are found two varieties known to transmit disease, viz., the *stegomyia* (yellow fever) and the *anopheles* (malarial fever). Thus far no evidence has been presented to show that other mosquitoes found in the United States act as a medium of infection. While the *anopheles* may be found throughout the United States the *stegomyia* is found only in the southern portion of it, which will explain why the propagation of yellow fever is confined to that section of the country. The most recent investigation of this subject relates to the *culex sollicitans*—commonly known as the "striped-legged," "salt-water," or "Atlantic coast" mosquito—of which but little has heretofore been known. This mosquito constitutes about 80 per cent. of those found along the Atlantic coast, and is the chief source of annoyance in the section referred to.

Until recently the extermination of the mosquito has been regarded as practically impossible, and within the past five or six years the propagation of certain species of birds, etc., for the purpose of diminishing the number of these insects, has been seriously suggested by those whose opinions are entitled to careful consideration. Indeed, efforts to exterminate the mosquito have heretofore been looked upon largely from a humorous point of view.

Careful investigation has shown that the extermination of the mosquito is not only practical, but can be successfully accomplished; besides, the public now know that the extermination of the mosquito is not alone for the purpose of preventing the annoyance which the bite of this insect inflicts, but also to prevent the transmission of disease. Therefore, to a considerable extent, the co-operation of the public has been secured in this important work.

To obtain success in our efforts to exterminate the mosquito we must be familiar with the manner in which it is propagated, its habits, etc. First, we must understand that all varieties of the mosquito propagate only in water. The importance of this lies in the fact that it gives us definite information regarding the character of their breeding places. Thus far investigation has shown that all mosquitoes, with the exception of the *sollicitans*, deposit their eggs on the surface of the water. These develop into larvæ, commonly known as "wigglers," and then into pupæ, which are subsequently transformed into the winged insects. From the deposit of the eggs to the development of the winged insect only twelve to twenty-five days elapse, depending on the variety of mosquito. The longest period is, as a rule, required for the development of the *anopheles*, or malarial mosquito. Until recently it has been the general belief that mosquitoes deposit their eggs only upon the surface of the water. The investigation of Dr. John B. Smith, State Entomologist of New Jersey, and the investigation under my direction have satisfactorily demonstrated the fact that the *sollicitans*, when free to act, deposit its eggs on the ground in the salt marshes along the coast, although in captivity this mosquito may deposit its eggs on water, glass, cotton, or on almost anything with which it comes in contact. However, even in captivity, it will be found that, if earth from salt marshes be placed in cages containing the *sollicitans*, it will preferably deposit its eggs on this material, however the development of the eggs do not take place until the earth is covered with water. In the salt marshes this is supplied by the frequent floodings, which form both small and large collections of water; many of these remain sufficiently long for the development of the winged insect. Therefore, while the eggs of the *sollicitans* are deposited on the earth in salt marshes, their development into the winged insects depends upon the presence of water in the same manner required by other varieties of the mosquito.

PROPAGATION OF THE MOSQUITO.

Culex Pungens. The *culex pungens*, the "inland" or "fresh-water" mosquito, is probably the most common variety of this insect with which we come in contact throughout the United States. It will breed in almost any receptacle containing water—commonly in cisterns, rain-water barrels, tin cans and other metal, glass, and wooden receptacles, roof leaders, crotches of trees, and in the most unsuspected places. My experience has shown that the propagation of this variety of mosquito is, as a rule, most active in stagnant and offensive water, which contains considerable organic matter. Two rather remarkable instances have recently come under my observation, where broken sewer pipes discharged their contents into ground depressions, resulting in collections of offensive water. In the immediate vicinity of these were pools of rain water, which were not contaminated. In both instances it was found that the sewer water soon became exceedingly rich in mosquito larvæ (culex pungens), whereas in the other pools, but a short distance away, and which contained comparatively clear water, there were few, if any, larvæ found. I have found additional proof of this in the following experiments: Large superficial wooden tanks were employed, in which water of various kinds were placed—*i. e.*, rain water, hydrant water, water in which decomposed meat, fish, etc., had been added. These tanks were exposed side by side in a section infested with mosquitoes. In all the tests it was shown that the deposit of mosquito eggs was always more numerous in tanks containing the offensive water. Experiments on a smaller scale were also made; pails and glasses were exposed, which contained the different kinds of water already referred to, with the same results—viz., the deposit of the eggs was much greater in the offensive water. These experiments were repeated many times with the same result, and are in harmony with the natural conditions, which I have found in districts infested with the *culex pungens*. Thus far I have found no evidence to prove that this variety of the mosquito will deposit its eggs on salt-water.

Anopheles or Malarial Mosquito. The anopheles, while it may sometimes be found breeding in the same receptacle with the *culex pungens*, generally selects for its breeding place small pools of water, commonly permanent ones, which are not contaminated, and which are frequently covered with green scum, or in water contained in small ground depressions, along the edge of swamps or pools of water, which are fed by springs, or in unused receptacles about the house.

Culex Sollicitans. The belief that no mosquito will breed in salt-water is erroneous, inasmuch as the *culex sollicitans* will breed in no other place. Therefore, while we suffer the annoyance which the bite of the *sollicitans* inflicts, it may be of some comfort to know that they will not breed inland or away from salt marshes. The statement just made regarding the *sollicitans* has been corroborated by careful investigation and experimental work which I have conducted during the past five years. During this period specimens of water containing larvæ taken from all kinds of receptacles about dwelling houses, ground depressions, etc., either in close proximity or some distance removed from salt-water swamps, were placed in large glass receptacles, covered with netting, and allowed to remain until the winged insects were developed, but in no instance did the *sollicitans* develop from these larvæ. A number of times larvæ have been taken from inland drains, the immediate vicinity of which was thickly infested with the *sollicitans*, but the larvæ always developed into the *culex pungens*, or "inland" mosquito, and no *sollicitans* were ever found. The result of these observations gradually directed attention to the salt marshes along the coast as the seat of propagation of the *sollicitans*. Here in the pockets, or ground depressions containing salt-water, the larvæ of this variety were found in enormous numbers, this was proven by placing the water containing larvæ in large glass jars covered with netting. When the winged insects appeared they were in every instance found to be the *sollicitans*, and no other variety. A series of experiments which followed consisted in the transfer of earth from these swamps to the laboratory, where it was placed in large glass jars covered with netting. In these were confined the *sollicitans*. Soon after their captivity eggs were found deposited on the earth. After the release of the mosquitoes the earth upon which the eggs had been deposited was kept intact and allowed to remain for various periods, in some instances for four months. In some of the tests the earth was kept moist; in others it was allowed to dry, but in no instance was there any further development of the eggs until the earth was covered with water; then, within twelve hours afterward, the larvæ appeared. Other experiments consisted in placing earth from salt-water marshes in wire cages also containing water in glass jars. The *sollicitans* in the cages preferably deposited their eggs on the earth rather than on the water. The results to which I have referred are in harmony with those obtained by Dr. John B. Smith, to whom credit is due for exceedingly valuable work in connection with this variety of mosquito.

As a result of these investigations it is reasonable to assume that the *culex sollicitans* breeds only in salt-water swamps, and that their eggs are deposited upon the earth and remain without further change until covered with water, when the developments of the winged insect rapidly follows. It is also reasonable to assume that the first crop of the *sollicitans*, which appear in the spring or early summer, is due to the hibernation of the eggs of this insect, which are deposited on the ground late in the fall, but do not develop until the warm weather of the following year appears, and the swamps are more or less covered with water.

On the other hand it is equally certain that the *culex pungens*, or "inland" mosquito, is perpetuated by the hibernation of the winged insect itself, and not by its eggs. It is a frequent occurrence in sections where this variety of the mosquito breeds to find a few of them about the house during the winter months. When the warm weather appears the survivors become active and deposit their eggs in receptacles containing water. It is not impossible that a few larvæ of this variety may hibernate during the winter, as in some instances they have been detected in ice, warmed and brought to life. However, I have never known of one which survived more than a short time, and I am quite certain that they do not play an important part in perpetuating their species. The statement which I have just made relative to the perpetuation of the *culex pungens* may, I believe, be also applied to the *anopheles* and *stegomyias*, although regarding the latter variety I do not speak from personal experience.

There is good reason to believe that the *stegomyia*, or yellow-fever mosquito, like the *culex pungens*, prefers to breed in contaminated water.

Psorophora Ciliata. It may be of interest to refer to my investigation concerning the variety of mosquito known as the *psorophora ciliata*. This variety is very large, probably three or four times the size of the ordinary mosquito; however, it is not frequently seen in this section of the country, and consequently is not much of a factor in the annoyance caused by these insects. I was fortunate enough during the past summer to secure four or five of this species. They were placed in captivity and many eggs were secured. The latter are not, like the eggs of the *culex pungens*, laid in floats consisting of three or four hundred, but in a manner similar to that of the *culex sollicitans*, which are fewer in number and separate from each other. In this instance the eggs developed into the larvæ in the ordinary way. These, however, gradually disappeared, and, after careful examination, it was found that *psorophora ciliata* is predatory and that the larvæ devour each other, and it was only by the introduction of plenty of larvæ of the *culex pungens*, which are much smaller and furnished sufficient food, that the larvæ of the former were preserved and some winged insects obtained. It is not improbable that the predatory habits of this variety will in a measure explain why there are so few of them.

LIFE OF THE MOSQUITO.

A general impression exists that the life of the mosquito is very short, probably a few days only. This is erroneous. While it is true that the mosquito is not a resistent insect and easily succumbs to all sorts of influences, it is a fact that it lives for some time. In the hibernating stage we know that it may live from fall until the following spring, and during the warm weather, or in its active stage, it may live a number of weeks. It is practically impossible to arrive at any definite conclusion regarding this part of the subject, inasmuch as experiments do not furnish satisfactory evidence, for the reason that they cannot be carried out under natural conditions. In other words, mosquitoes may die from captivity or fright, or when they are unable to select the character of food which they require. It is safe to assume, however, that if they live a certain period in captivity they will live equally long when they are free to go and come as they please. There have been many investigations made and published on this point which proves that mosquitoes will live for weeks in captivity. I have kept them under observation in wire cages with nothing but sugar-water for two months. They may be kept for a long period in captivity without food or water, provided air and light be present. Aside from the importance of securing definite knowledge in this direction, the length of time which mosquitoes may live in close confinement without air or light has an important practical bearing, as it has been claimed that yellow fever may be transmitted from one place to another through the agency of infected *stegomyia*, or yellow fever mosquito, confined in baggage, etc. In order to secure so far as possible definite information regarding this part of the subject, the following experiments were made:

A number of boxes, canvas bags, and other receptacles were filled with clothing, blankets, bedding, etc. When these were made ready mosquitoes were collected in the following manner: Horses were taken to a district thickly infested with mosquitoes, where they were soon covered with these insects; over which were placed test tubes, in order to secure the mosquitoes uninjured. When a sufficient number were caught in this manner, the opening of the tubes were filled with light cotton plugs, and within a short time afterward the tubes were introduced into the receptacles already described, the cotton plugs removed, and the tubes gradually withdrawn, being shaken sufficiently to drive out the mosquitoes. In this manner, from the time of the capture of the mosquitoes until their introduction into the receptacles, they were neither handled nor in any way injured; certainly, no more than they would be if imprisoned during the process of packing. A careful record was kept of the number of mosquitoes in each receptacle in order that all could be accounted for, and although many experiments were made, it was found that in no instance did the mosquitoes survive the confinement longer than thirty hours. I believe, therefore, that the treatment of baggage coming from yellow-fever ports is unnecessary, provided the period of transit exceeds two days.

DISTANCE WHICH MOSQUITOES TRAVEL.

Considerable difference of opinion exists in regard to the distance which mosquitoes travel. While there is sufficient proof that they are sometimes found a long way from home, careful investigation has shown that, with the exception of the *culex sollicitans*, they do not willingly go far from their breeding place. The fact that the *sollicitans* breeds only in salt-water swamps along the coast and are always found some distance inward is evidence enough that this is the habit of the *sollicitans*, and is not due to accidental causes. However, the *culex pungens*, *anopheles*, and the *stegomyia* are notoriously home mosquitoes and remain in close proximity to their breeding place, unless forcibly removed by winds, etc., and there is no doubt that the difference of opinion, which exists in reference to this part of the subject, particularly in regard to the varieties just referred to, is due principally to the fact that local breeding places are frequently overlooked. When it is remembered that the female of the *culex pungens* variety will lay three or four hundred eggs at one time, and as it only requires from twelve to twenty-five days for eggs to develop into a winged insect, it is not difficult to understand how a small receptacle will breed a large number of mosquitoes. Therefore we should first examine every part of our premises to discover the breeding places of mosquitoes before we look elsewhere for them. As a matter of fact, these are usually found in the most unsuspected places. I will cite an instance occurring in my own experience some time ago. My attention was called to a number of cases of malarial fever occurring in two or three houses in close proximity to each other. *Anopheles* were found in the rooms of these dwellings during the evening. In the immediate vicinity of the houses were found numerous pools of water, rain-water barrels, and other receptacles containing water, which were examined with great care, but no *anopheles* larvæ found. Continued investigation was made and in the garden of a vacant house adjoining those where malarial fever existed was found an old cake pan, almost entirely covered with long grass, but filled with *anopheles* larvæ. An ordinary inspection would probably not have discovered this receptacle.

EXTERMINATION OF THE MOSQUITO.

Careful investigation of the mosquito has shown that the various types of this insect differ in their method of propagation, habits, etc. It is very necessary that we should be familiar with this fact, inasmuch as the means by which the mosquito may be exterminated depend largely upon the variety with which we have to deal.

The importance of our present knowledge regarding the *culex sollicitans* will be better appreciated by those who live along the Atlantic coast, and who are constantly subjected to the annoyance of this variety of the mosquito during the warm weather. It is a well-known fact that the enormous number of *sollicitans* present has seriously interfered with the development of certain sections along the Atlantic coast. Before its breeding place was definitely known efforts to prevent its propagation were confined to the same means which are used to exterminate the *culex pungens*, *anopheles*, and *stegomyia*, such as the care of inland ground depressions, cisterns, rain-water barrels, and other receptacles. We now know that such methods as these are practically useless in the extermination of the *sollicitans*, and it is only by the proper drainage of salt-water swamp lands along the coast that the propagation of this variety can be prevented. The use of oil in the extermination of this variety of mosquito even as a temporary measure is but of little or no value. Although the *sollicitans* deposits its eggs on the ground in the swamps, they cannot develop without water, and, if accumulations of surface water is prevented by drainage, propagation ceases. This has already been successfully demonstrated in some of the New Jersey salt-water swamps, which were impassible and thickly infested with mosquitoes. These have recently been ditched and drained, and this year are producing crops of hay, which are harvested with mowing machines. Furthermore, the mosquito has practically disappeared in the sections thus treated. Work of a similar character is now in progress along the Staten Island coast, and it is confidently expected that next year will prove the success of this work.

In inland districts which are infested with the *culex pungens*, and other "fresh water" or "inland" mosquitoes, it is imperative that the public should be instructed not only in regard to the necessity for drainage and filling in where land depressions exist, but also the importance of removing so far as possible from dwelling houses and other buildings and about the premises all sorts of metal, glass, and wooden receptacles which contain water and which may act as breeding places. This policy has been carried out during the past summer in connection with the mosquito work on Staten Island. About ten thousand circulars were distributed throughout the residential portion of the Island, giving general information in regard to this mosquito, its breeding places, and the means by which it may be exterminated. The result has shown that this method of securing the co-operation of the public is practical and successful. Cisterns and rain-water barrels contribute largely toward the propagation of the *culex pungens*. If more modern means of securing water cannot be substituted, these receptacles should be supplied with tight-fitting covers, the centre of which may be constructed of wire netting to admit air. Roof leaders should be kept properly graded, otherwise parts of them may act as breeding places. If ground depressions either about the premises or in the neighborhood cannot be drained or filled in, petroleum oil may be used as a temporary measure. The crude petroleum, of which the so-called "Lima" oil is a type, is probably superior to the refined oil, and should be used in proportion of one pint of oil to a water surface of about twenty feet in diameter. Even a less amount of oil may be effective. This procedure should be repeated every two weeks. The method by which the oil destroys the larvæ, or "wiggler," is probably not by a toxic effect, but by a mechanical one. The larvæ must come to the surface of the water for air every minute or two. If watched carefully it will be noticed that the *culex* approach the surface of the water at right angles with the tail uppermost and extended somewhat above the surface, the air being taken in at this end. The *anopheles* larvæ may be distinguished at this stage, for the reason that they do not lie at right angles to the surface of the water, but underneath and parallel to it, and receive the air by projecting the head above the water instead of the tail. It is probable that the oil thrown on the surface obstructs the delicate respiratory apparatus of the larvæ and rapidly suffocates them. This is largely corroborated by experiments. If a small amount of petroleum oil is thrown over the surface of the water in a glass jar containing larvæ the latter will succumb in from ten to twenty minutes; toxic agents kill them very slowly, as careful investigation has proved. The odor of petroleum oil is evidently very unpleasant to the winged insect, inasmuch as the exposure of this agent diminishes the number of mosquitoes present. In treating water surfaces with petroleum the ordinary garden sprinkling-pot, with the openings in the nozzle somewhat enlarged, is a good and practical method of distributing it. My experiments with permanganate of potassium, bichloride of mercury, sulphate of copper, carbolic acid, etc., have shown that these agents are greatly inferior to petroleum for the purpose of destroying larvæ. Their action is slow, and the mosquito larvæ live in comparatively strong solution; for instance, larvæ have remained more or less active from one to two days in a 1:1500 solution of bichloride of mercury. Even comparatively strong solutions of carbolic acid or permanganate of potassium do not destroy them for some time. In some very exhaustive experiments made with sulphate of copper and lime for the destruction of mosquito larvæ, etc.,[1] I found that these agents did not destroy the mosquito by a toxic effect, but slowly by clarifying the water and precipitating the organic matter, which was contained in the receptacle, thereby removing the nourishment upon which the larvæ depended. It must be remembered that pools of water throughout the country may be used for drinking purposes, by animals, and that the use of such agents as bichloride of mercury, carbolic acid, etc., are therefore unsafe and should never be used. On the other hand, petroleum oil is cheap, practically harmless, and destroys the larvæ at once, and, so far as we know at the present time, is superior to anything else as a temporary measure.

Mosquitoes are most active after sundown. During the day they often select for their abiding place the high grass and underbrush. Therefore this material, so far as possible, should be removed in mosquito-infested districts.

It is apparent from a careful study of this subject that all varieties of the mosquito cannot be exterminated by the same means. For instance, in the case of the *sollicitans*, it is absolutely necessary that the work of extermination should be carried out under municipal, State, or Federal control in order to insure uniform and successful results. Ditching or draining here and there according to the will of individual owners of salt-water swamp land will only end in failure to successfully exterminate this variety of the mosquito. On the other hand, the extermination of the *culex pungens*, *anopheles* and *stegomyia* depends largely on the efforts which are made by individual property owners or tenants to prevent the propagation of this mosquito in receptacles about the premises, as well as the draining and filling in of ground depressions.

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[1] Medical Record, January 31, 1905.

The theory that filth favors the propagation of yellow fever is entitled to the most respectful consideration, inasmuch as bad drainage, and the accumulation of fluid filth, etc., furnishes the breeding place for the *stegomyia*. Since the knowledge has come to us that the mosquito is the medium by which yellow fever is transmitted, the fact that filth contributes indirectly to this disease has unfortunately been overlooked.

CYSTINURIA.

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The occurrence of cystin in the urine has attracted the attention of many investigators, and more or less complete attempts have been made to control the metabolism and to explain the relationships of this most curious metabolic anomaly.

In 1876 Loebisch[1] undertook what was for that time a careful investigation of the condition, and showed, in contradistinction to the findings of the older observers, cystin was not increased at the expense of the uric acid.

Later Mester,[2] under Baumann's guidance, had the opportunity of examining, during a long period, a pronounced case of cystinuria, in which he was able to control the diet. It cannot be said that the results of Mester throw any very distinct light on the effects of various procedures, such as diet, alcohol, massage, on the excretion of the cystin.

More recently, however, renewed attention has been directed to the condition by the work of Mörner,[3] who has demonstrated that the cystin group is a constituent of all protein substances, and of Friedmann,[4] who has cleared up the chemical constitution of cystin.

From a physiological point of view the subject of cystinuria has come into the front rank of importance through the recent and very remarkable results of Loewy and Neuberg.[5] If the results of these investigators hold, and the theories advanced as a consequence of this work be correct, they have contributed a very fundamental research to the physiology of nutrition.

As, however, their results have not been confirmed by other observers,[6] any light which can be thrown on this important anomaly is of value. It is for the purpose of contributing to the meagre data obtaining that the following two analyses of the urine are given.